National Science Framework for Grades 3-5

Eight practices to be essential elements of the K-12 science and engineering curriculum:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

SEVEN CROSSCUTTING CONCEPTS OF THE FRAMEWORK

The committee identified seven crosscutting scientific and engineering concepts:
1. *Patterns.* Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. *Cause and effect: Mechanism and explanation*. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity.* In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models.* Defining the system under study—specifying its boundaries
and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter: Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function.* The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. *Stability and change.* For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.

Compiled by Dave Shellhaas from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* ISBN 978-0-309-21742-2

PHYSICAL SCIENCE

Core and Component Ideas in the Physical Sciences

Core Idea PS1: Matter and Its Interactions
- PS1.A: Structure and Properties of Matter
- PS1.B: Chemical Reactions
- PS1.C: Nuclear Processes

Core Idea PS2: Motion and Stability: Forces and Interactions
- PS2.A: Forces and Motion
- PS2.B: Types of Interactions
- PS2.C: Stability and Instability in Physical Systems

Core Idea PS3: Energy
- PS3.A: Definitions of Energy
- PS3.B: Conservation of Energy and Energy Transfer
- PS3.C: Relationship Between Energy and Forces
- PS3.D: Energy in Chemical Processes and Everyday Life

Core Idea PS4: Waves and Their Applications in Technologies for Information Transfer
- PS4.A: Wave Properties
- PS4.B: Electromagnetic Radiation
- PS4.C: Information Technologies and Instrumentation.

CORE IDEA PS1: MATTER AND ITS INTERACTIONS

How can one explain the structure, properties, and interactions of matter?

PS1.A: Structure and Properties of Matter

How do particles combine to form the variety of substances one observes?

- ***By the end of grade 5.*** Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). For example, a model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations including: the impacts of gas particles on surfaces (e.g., of a balloon) and on larger particles or objects (e.g., wind, dust suspended in air), and the appearance of visible scale nwater droplets in condensation, fog, and, by extension, also in clouds or the contrails of a jet. The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (e.g., sugar in solution, evaporation in a closed container). Measurements of a variety of properties (e.g., hardness, reflectivity) can be used to identify particular substances.
- (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation).

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PS1.B: Chemical Reactions
How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?

- ***By the end of grade 5.*** When two or more different substances are mixed, a new substance with different properties may be formed; such occurrences depend on the substances and the temperature. No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)

PS1.C: Nuclear Processes
What forces hold nuclei together and mediate nuclear processes?

- ***By the end of grade 5.*** Intentionally left blank.

CORE IDEA PS2: MOTION AND STABILITY: FORCES AND INTERACTIONS

How can one explain and predict interactions between objects and within systems?

PS2.A: Forces and Motion
How can one predict an object's continued motion, changes in motion, or stability?

- ***By the end of grade 5.*** Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they counterbalance one another. Forces that are not counterbalanced can cause changes in the object's speed or direction of motion. The patterns of an object's motion in various situations can be observed; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)

PS2.B: Types of Interactions
What underlying forces explain the variety of interactions observed?

- ***By the end of grade 5***. Objects in contact exert forces on each other (friction, pressure,pushes and pulls). Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. The force of gravity of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

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PS2.C: Stability and Instability in Physical Systems

Why are some physical systems more stable than others?

- ***By the end of grade 5***. A system can change as its processes move in one direction (e.g., a ball rolling down a hill), shift back and forth (e.g., a swinging pendulum), or go through cyclical patterns (e.g., day and night). Examining how a system's internal forces change as it moves can help explain the system's patterns of change. A system can appear to be unchanging when processes within the system are going on at opposite but equal rates (e.g., water in a dam is at a constant height because water is flowing in at the same rate that water is flowing out). Changes can happen very quickly or very slowly and are sometimes hard to see (e.g., plant growth). Conditions and properties of the objects within a system affect how fast or slowly a process occurs (e.g., heat conduction).

CORE IDEA PS3: ENERGY

How is energy transferred and conserved?

PS3.A: Definitions of Energy

What is energy?

- ***By the end of grade 5.*** The faster a given object is moving, the more energy it possesses. Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)

PS3.B: Conservation of Energy and Energy Transfer

What is meant by conservation of energy?
How is energy transferred between objects or systems?

- ***By the end of grade 5.*** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. Light also transfers energy from place to place. For example, energy radiated from the sun is transferred to the earth by light. When this light is absorbed, it warms Earth's land, air, and water and facilitates plant growth. Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with from the energy of motion (e.g., moving water driving a spinning turbine).

PS3.C Relationship Between Energy and Forces
How are forces related to energy?

- ***By the end of grade 5.*** When objects collide, the contact forces transfer energy so as to change the objects' motions. Magnets can exert forces on other magnets or on magnetizable materials, thereby transferring energy (e.g., in the form of motion) even when the objects are not touching.

PS3.D: **Energy in Chemical Processes and Everyday Life**
How do food and fuel provide energy?
If energy is conserved, why do people say it is produced or used?

- ***By the end of grade 5.*** The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use—for example, the stored energy of water behind a dam is released so that it flows downhill and drives a turbine generator to produce electricity. Food and fuel also release energy when they are burned or digested. When machines or animals "use" energy (e.g., to move around), most often the energy finishes up transferred to heat in the surrounding environment. The energy released by burning fuel or digesting food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (Boundary: The fact that plants capture energy from sunlight is introduced at this grade level, but details of photosynthesis are not.) It is important to be able to concentrate energy so that it is available for use where and when it is needed. For example, batteries are physically transportable energy storage devices, whereas electricity generated by power plants is transferred from place to place through distribution systems.

CORE IDEA PS4: WAVES AND THEIR APPLICATIONS IN TECHNOLOGIES FOR INFORMATION TRANSFER

How are waves used to transfer energy and information?

PS4.A: Wave Properties
What are the characteristic properties and behaviors of waves?

- ***By the end of grade 5.*** Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) Earthquakes cause seismic waves, which are waves of motion in Earth's crust.

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PS4.B: Electromagnetic Radiation
What is light?
How can one explain the varied effects that involve light?
What other forms of electromagnetic radiation are there?

- ***By the end of grade 5.*** A great deal of light travels through space to Earth from the sun and from distant stars. An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface. (Boundary: This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.) Because lenses bend light beams, they can be used, singly or in combination, to provide magnified images of objects too small or too far away to be seen with the naked eye.

PS4.C: Information Technologies and Instrumentation
How are instruments that transmit and detect waves used to extend human senses?

- ***By the end of grade 5.*** Lenses can be used to make eyeglasses, telescopes, or microscopes in order to extend what can be seen. The design of such instruments is based on understanding how the path of light bends at the surface of a lens. Digitized information (e.g., the pixels of a picture) can be stored for future recovery or transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (Boundary: At this grade level, no attempt is made to explain these technologies, but students should recognize that "high tech" often connotes applied knowledge of waves, matter, and their interactions.)

LIFE SCIENCE

Core and Component Ideas in Life Sciences

Core Idea LS1: From Molecules to Organisms: Structures and Processes
- LS1.A: Structure and Function
- LS1.B: Growth and Development of Organisms
- LS1.C: Organization for Matter and Energy Flow in Organisms
- LS1.D: Information Processing

Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics
- LS2.A: Interdependent Relationships in Ecosystems
- LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- LS2.D: Social Interactions and Group Behavior

Core Idea LS3: Heredity: Inheritance and Variation of Traits
- LS3.A: Inheritance of Traits
- LS3.B: Variation of Traits

Core Idea LS4: Biological Evolution: Unity and Diversity
- LS4.A: Evidence of Common Ancestry and Diversity
- LS4.B: Natural Selection
- LS4.C: Adaptation
- LS4.D: Biodiversity and Humans

CORE IDEA LS1: FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

How do organisms live, grow, respond to their environment, and reproduce?

LS1.A: Structure and Function

How do the structures of organisms enable life's functions?

- ***By the end of grade 5.*** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (Boundary: Stress at this grade level is on understanding the macroscale systems and their function, not microscopic processes.)

LS1.B: Growth and Development of Organisms

How do organisms grow and develop?

- ***By the end of grade 5.*** Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and eventually dying.

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LS1.C: Organization for Matter and Energy Flow in Organisms
How do organisms obtain and use the matter and energy they need to live and grow?

- ***By the end of grade 5.*** Animals and plants alike generally need to take in air and water, animals must take in food, and plants need light and minerals; anaerobic life, such as bacteria in the gut, functions without air. Food provides animals with the materials they need for body repair and growth and is digested to release the energy they need to maintain body warmth and for motion. Plants acquire their material for growth chiefly from air and water and process matter they have formed to maintain their internal conditions (e.g., at night).

LS1.D: Information Processing
How do organisms detect, process, and use information about the environment?

- ***By the end of grade 5.*** Different sense receptors are specialized for particular kinds of information, which may then be processed and integrated by an animal's brain, with some information stored as memories. Animals are able to use their perceptions and memories to guide their actions. Some responses to information are instinctive—that is, animals' brains are organized so that they do not have to think about how to respond to certain stimuli.

CORE IDEA LS2: ECOSYSTEMS: INTERACTIONS, ENERGY, AND DYNAMICS

How and why do organisms interact with their environment, and what are the effects of these interactions?

LS2.A: Interdependent Relationships in Ecosystems
How do organisms interact with the living and nonliving environment to obtain matter and energy?

- ***By the end of grade 5.*** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Either way, they are "consumers." Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil for plants to use. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.

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LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
How do matter and energy move through an ecosystem?

- ***By the end of grade 5***. Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, water, and minerals from the environment and release waste matter (gas, liquid, or solid) back into the environment.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
What happens to ecosystems when the environment changes?

- ***By the end of grade 5.*** When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.

LS2.D: Social Interactions and Group Behavior
How do organisms interact in groups so as to benefit individuals?

- ***By the end of grade 5.*** Groups can be collections of equal individuals, hierarchies with dominant members, small families, groups of single or mixed gender, or groups composed of individuals similar in age. Some groups are stable over long periods of time; others are fluid, with members moving in and out. Some groups assign specialized tasks to each member; in others, all members perform the same or a similar range of functions.

CORE IDEA LS3: HEREDITY: INHERITANCE AND VARIATION OF TRAITS

How are characteristics of one generation passed to the next?
How can individuals of the same species and even siblings have different characteristics?

LS3.A: Inheritance of Traits
How are the characteristics of one generation related to the previous generation?

- ***By the end of grade 5.*** Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.

LS3.B: Variation of Traits
Why do individuals of the same species vary in how they look, function, and behave?

- ***By the end of grade 5.*** Offspring acquire a mix of traits from their biological parents. Different organisms vary in how they look and function because they have different inherited information. In each kind of organism there is variation in the traits themselves, and different organisms may have different versions of the trait. The environment also affects the traits that an organism develops—differences in where they grow or in the food they consume may cause organisms that are related to end up looking or behaving differently.

IDEA LS4: BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?
How does biodiversity affect humans?

LS4.A: Evidence of Common Ancestry and Diversity
What evidence shows that different species are related?

- ***By the end of grade 5.*** Fossils provide evidence about the types of organisms (both visible and microscopic) that lived long ago and also about the nature of their environments. Fossils can be compared with one another and to living organisms according to their similarities and differences.

LS4.B: Natural Selection
How does genetic variation among organisms affect survival and reproduction?

- ***By the end of grade 5.*** Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

LS4.C: Adaptation
How does the environment influence populations of organisms over multiple generations?

- ***By the end of grade 5.*** Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

LS4.D: Biodiversity and Humans

What is biodiversity, how do humans affect it, and how does it affect humans?

- ***By the end of grade 5.*** Scientists have identified and classified many plants and animals. Populations of organisms live in a variety of habitats, and change in those habitats affects the organisms living there. Humans, like all other organisms, obtain living and nonliving resources from their environments.

EARTH SCIENCE

Core and Component Ideas in Earth and Space Sciences

Core Idea ESS1: Earth's Place in the Universe

- ESS1.A: The Universe and Its Stars
- ESS1.B: Earth and the Solar System
- ESS1.C: The History of Planet Earth

Core Idea ESS2: Earth's Systems

- ESS2.A: Earth Materials and Systems
- ESS2.B: Plate Tectonics and Large-Scale System Interactions
- ESS2.C: The Roles of Water in Earth's Surface Processes
- ESS2.D: Weather and Climate
- ESS2.E: Biogeology

Core Idea ESS3: Earth and Human Activity

- ESS3.A: Natural Resources
- ESS3.B: Natural Hazards
- ESS3.C: Human Impacts on Earth Systems
- ESS3.D: Global Climate Change

CORE IDEA ESS1: EARTH'S PLACE IN THE UNIVERSE

What is the universe, and what is Earth's place in it?

ESS1.A: The Universe and Its Stars

What is the universe, and what goes on in stars?

- ***By the end of grade 5.*** The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.

ESS1.B: Earth and the Solar System

What are the predictable patterns caused by Earth's movement in the solar system?

- ***By the end of grade 5.*** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the moon; and different positions of the sun, moon, and stars at different times of the day, month, and year. Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth's rotation.

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ESS1.C: The History of Planet Earth

How do people reconstruct and date events in Earth's planetary history?

- ***By the end of grade 5.*** The earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help to infer the history of the current landscape. Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. Patterns of tree rings and ice cores from glaciers can help reconstruct Earth's recent climate history.

CORE IDEA ESS2: EARTH'S SYSTEMS

How and why is the earth constantly changing?

ESS2.A: Earth Materials and Systems

How do the major earth systems interact?

- ***By the end of grade 5.*** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. Human activities affect Earth's systems and their interactions at its surface.

ESS2.B: Plate Tectonics and Large-Scale System Interactions

Why do the continents move, and what causes earthquakes and volcanoes?

- ***By the end of grade 5.*** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Earthquakes happen near or deep below Earth's surface, volcanoes are found on the continents and on the ocean floor, and major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features where people live and in other areas of Earth.

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ESS2.C: The Roles of Water in Earth's Surface Processes
How do the properties and movements of water shape Earth's surface and affect its systems?

- ***By the end of grade 5.*** Water is found almost everywhere on Earth: as humidity; as fog or clouds in the atmosphere; as rain or snow falling from clouds; as ice, snow, and running water on land and in the ocean; and as groundwater beneath the surface. The downhill movement of water as it flows to the ocean shapes the appearance of the land. Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.

ESS2.D: Weather and Climate
What regulates weather and climate?

- ***By the end of grade 5.*** Weather is the minute-by-minute to day-by-day variation of the atmosphere's condition on a local scale. Scientists record the patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes the ranges of an area's typical weather conditions and the extent to which those conditions vary over years to centuries.

ESS2.E: Biogeology
How do living organisms alter Earth's processes and structures?

- ***By the end of grade 5.*** Living things affect the physical characteristics of their regions (e.g., plants' roots hold soil in place, beaver shelters and human-built dams alter the flow of water, plants' respiration affects the air). Many types of rocks and minerals are formed from the remains of organisms or are altered by their activities.

CORE IDEA ESS3: EARTH AND HUMAN ACTIVITY

How do Earth's surface processes and human activities affect each other?

ESS3.A: Natural Resources
How do humans depend on Earth's resources?

- ***By the end of grade 5.*** All materials, energy, and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

ESS3.B: Natural Hazards
How do natural hazards affect individuals and societies?

- ***By the end of grade 5.*** A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.

ESS3.C: Human Impacts on Earth Systems
How do humans change the planet?

- ***By the end of grade 5.*** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities.

ESS3.D: Global Climate Change
How do people model and predict the effects of human activities on Earth's climate?

- ***By the end of grade 5.*** If Earth's global mean temperature continues to rise, the lives of humans and other organisms will be affected in many different ways..

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ENGINEERING, TECHNOLOGY, AND APPLICATION OF SCIENCE

Core and Component Ideas in Engineering, Technology, and Application of Science

Core Idea ETS1: Engineering Design

- ETS1.A. Defining and Delimiting an Engineering Problem
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

Core Idea ETSA2: Links Among Engineering, Technology, Science, and Society

- ETS2.A: Interdependence of Science, Engineering, and Technology
- ETS2.B: Influence of Engineering, Technology and Science
- on Society and the Natural World

CORE IDEA ETS1: ENGINEERING DESIGN

How do engineers solve problems?

ETS1.A. Defining and Delimiting an Engineering Problem

What is a design for?
What are the criteria and constraints of a successful solution?

- ***By the end of grade 5.*** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

What is the process for developing potential design solutions?

- ***By the end of grade 5.*** Research on a problem should be carried out—e.g., through Internet searches, market research, or field observations—before beginning to design a solution. An often-productive way to generate ideas is for people to work together to brainstorm, test, and refine possible solutions. Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

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ETS1.C: Optimizing the Design Solution

How can the various proposed design solutions be compared and improved?

- ***By the end of grade 5.*** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

CORE IDEA ETS2: LINKS AMONG ENGINEERING, TECHNOLOGY, SCIENCE, AND SOCIETY

How are engineering, technology, science, and society interconnected?

ETS2.A: Interdependence of Science, Engineering, and Technology

What are the relationships among science, engineering, and technology?

- ***By the end of grade 5.*** Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. Knowledge of relevant scientific concepts and research findings is important in engineering.

ETS2.B: Influence of Engineering, Technology and Science on Society and the Natural World

How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world?

- ***By the end of grade 5.*** Over time, people's needs and wants change, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), to decrease known risks (e.g., seatbelts in cars), and to meet societal demands (e.g., cell phones). When new technologies become available, they can bring about changes in the way people live and interact with one another.

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